Technology Revolutions, Their Implications and NASA LaRC Technology Capabilities Overview

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The (Economic) Ages of Humankind

- Hunter/Killer groups (~1 Million - ~5K BC)
- Agriculture (~5K BC - ~1850 AD)
- Industrial (~1850 AD - ~1950 AD)
- Information/Bio/Nano (~1950 AD - ~2030 AD)
- Virtual (~2030 - ?)

The (Economic) Ages of Humankind (cont'd)

- Hunter-Gatherer - "Nature Provided"
- Agriculture - <u>Controlled</u> Nature (Plants/Animals), enabled civilization
- Industrial - <u>Mechanized</u> Agriculture (1800's--97% Farmers, Now--2%)
- IT/Bio/Nano - <u>Automating</u> Industry/Agriculture (1950's--60%, Now--11%, heading to 2%)
- Virtual - <u>Robotization</u> of IT/Bio/Nano/Industry/Agriculture (tbd)
- <u>Technology MATTERS</u> - For both good & ill…

"Entering the age of the small, the fast, the smart, and the many…."

(and the inexpensive)

The Key Technologies
(highly synergistic/at the frontiers of the small/in a "feeding frenzy" off each other)

- ## IT
  - comms, computing, sensors, electronics, machine intelligence

- ## Bio
  - genomics, molecular biology, designer life forms

- ## Nano
  - coatings, barriers, computers, sensors, materials, "assemblers"

The Key Technologies (cont'd)
(highly synergistic/at the frontiers of the small/in a "feeding frenzy" off each other)

- <u>Energetics</u>
  - HEDM (various)/revolutionary solar, biomass, explosives, propellants, storage

- <u>Quantum</u>
  - crypto, computing, sensors, optics, electronics

- <u>Societal Technological Systems</u>
  - motivational asynchronous "distance learning," immersive/virtual presence, "tele-everything," "robotic everything," digital earth/digital airspace

Worldwide IT Revolution

- Comms/Computing/Sensors/Electronics
- Factor of E07 since '59 (Moore's Law)
- Factor of E08 to E12 further improvement (Silicon, Molecular/CNT, Quantum, Bio, Optical)
- Beyond Human Machine Intelligence?
- Automatics/Robotics "in the large"
- Immersive multi-sensory VR/"Holodecks"
- Ubiquitous multi-physics/hyperspectral sensors (land/sea/air/space)

Impacts of On-Going
IT Revolution Upon Society

- Work (at home telecommuting, reduced local/corporal travel)

- Shopping (at home, web-based, (robotic?) delivery)

- Entertainment/leisure (at home immersive 3-D interactive/multi-sensory via VR/holographic projection)

- Travel (3-D/interactive/multi-sensory <u>tele-travel</u>)

Impacts of On-Going
IT Revolution Upon Society (cont'd)

- Education (at home, low cost asynchronous, web-based on-demand, highly motivational, life-long distance learning, .edu)
- Health (at home interactive tele-medicine)
- Politics (increased real-time virtual involvement of the body politic)
- Commerce (tele-commerce already ubiquitous)
- Tele-Socialization, tele-(onsite) Manufacturing

Wild Card…..

- The extent to which "socialization" via "virtual presence" will "replace" and possibly improve "physical presence" socialization

- It really is "all in our heads" -- silicon implants and optical comms will enable superb five-senses, instantaneous, immersive presence including Haptic Touch, etc. – "Better than Real"….and not limited to reality (i.e., 'Second Life' and all that…)

Machine Intelligence

- Approaches:
  - Experiential – behavior-based/"learning" (neural nets/other "soft computing")
  - Nano-section/replicate brain in silicon
  - "Emergence"

- Should produce artificial/cyber "life" which will possibly-to-probably be sentient but will not be anthropomorphic

Summary - Bio "Futures"

- [Serious] human life extension and human "amplification"

- 'Pharm" animals

- "Borged up" humans

- "Designer life forms"

- Bio-mimetic, bio-production and bio-functionalism

- Bio-energy sources

Nano Technology

- <u>Coatings/Barriers</u> (thermal, radiation, abrasive, recording, combined sensors/effectors/signature/comms, single molecule sensors)

- <u>Computers</u> (molecular/petaflop and beyond computing)

- <u>Materials</u> [SWCNT's/NNT's (ultra high strength-to-weight) high surface area for catalysis, sieves, filters, absorption]

- "Assemblers?" (changes EVERYTHING -- e.g., economics, exploration, manufacture)

Quantum Technology Arenas

- Quantum cryptography keyes
- Materials (nano at the quantum limit, magnetics)
- Sensors (include quantum well Infrared detectors)
- Computing (progressing very rapidly, petaflops and beyond)
- Imaging ("interaction free," Quantum holography, NMR)
- Information systems
- Communications (instantaneous irrespective of distance, usefulness TBD)
- Optical systems (e.g. quantum interferometry)
- "Electronics"
- Zero point energy

Future(s) of "Design"

- Increasingly, machines do the design & engineering

- End user/consumer specifies functionality

- On-site "symbolic manipulation"/ ("certified") software provides completed design/option(s) to user for selection ("user-friendly" Brilliant Pro-Engineer on Steroids)

- Selected design sent to on-site manufacturing equipment

Prospective "Future(s)" of Manufacturing

- Nano-assemblers - manufacture at home, purchase the "software"/instruction set over the web (Now - printable mechatronics, free-form fab, "RepRap" (mm-to-30 cm), "Fab Labs")
- Bio-production - manufacture at home, purchase DNA/genomic instruction sets over the web. Many of the "products" could/would be "living" (bio-functionalism)-

Enabled Personal "Independence"

- "Self-Sufficient Electronic Cottages" widely dispersed ("30 acres on a mountaintop")
- Physical access via (robotic) personal STOL air delivery and transportation vehicles ($50K each, fly/drive)

- Nano plastic solar PV and local biomass energy sources, genomic biologics for H2

- "Recycling" [water, waste,.....]

Enabled Personal "Independence"
(cont'd)

- (Primarily) <u>virtual</u>/electronic (3-D, immersive, multi-sensory)
- Tele-commuting, tele-shopping
- Tele-commerce, tele-entertainment
- Tele-travel, tele-medicine
- Tele-education, tele-socialization
- Tele-politics, tele-[onsite] "Manufacturing" including food

Petroleum (Transportation Fuel) Outlook

- In general, "cheap oil" production is peaking or has peaked. Residual supplies will have greater production costs. Increasing petroleum demand, particularly from the developing world, will ensure ever increasing oil prices and shifts, from purely economic drivers, to "alternatives" (H2, Biomass)

- Demand example - U.S. has 745 vehicles per 1,000 population. China, the second largest oil importer, has 3 vehicles per 1,000 population. If China goes to 5 vehicles per 1,000 population, they will have to DOUBLE their oil imports to 10 million barrels/day

Energetics in the "Post-Petroleum" Age

- BioMass via seawater agriculture on wastelands (i.e., land, water, food, energy, warming)
- Plastic nano PV, concentrators
- Advanced geothermal
- Tidal currents
- Genomic bacteria H2 production
- Artificial photo-synthesis H2 production
- Photo-catalytic electrolysis of H2O
- H-B11 fusion, LENR's
- Conservation via "light diodes," thermal diodes, CNT computing,"tele-everything," fuel cells, CNT-enabled weight reductions

Global Warming "Solutions"

- Green energy
- Conservation
- Genomic biologics w/greatly increased CO2 uptake
- Trigger calderas (nascent volcanoes) -- put massive amounts of dust in the atmosphere
- Nano-particulates spread on the monolayer of surfactant on the oceans' surface to alter albedo
- Gigantic reflective films/membranes in orbit
- Seed oceans with iron to provoke/enable phytoplankton blooms

Employment

- We are in a "jobless" economic recovery. (i.e., large numbers of jobs are "missing")

- Some 1/3rd of the "missing jobs" went out of the country (globalization/outsourcing of WHITE COLLAR/"service" jobs)

- Rest of the jobs "disappeared" due to ever-improving automation/robotics/IT. There are very few-to-no jobs the machines cannot do…….

Employment (cont'd)

- The machines create "wealth," cost of goods on a rapid downward spiral

- The OUTLOOK -- continuing rapid erosion of high-level employment. No "human unique" jobs in the offing. "What the people will do all day" a serious issue…….

"Interesting Times". . .Within Some 25 years. . .

- Increases in human life span of 1 year/year…

- Machine intelligence approaching-to-beyond human, networked global sensor grid/Global "Mind"

- Individual (Bio, IO, Nano) capability to take down the species

"Interesting Times". . .Within Some 25 years. . . (cont'd)

- Machines/robotics take-over "employment," produce wealth for EVERYONE -- molecular manufacturing

- Humans become cyborgs far more than today (brain and body)

- Revolutionary energy sources/storage

    (nearly) everything goes VIRTUAL

THE Fundamental Problem Going Forward

- In the Industrial Age, wealth was created by exploiting natural resources. The U.S. was exceedingly rich in nearly all such resources (river/water transport, minerals, farmland, etc) – the reason for our Industrial Age economic dominance.

- In the current Information Technology Age, wealth is created by inventing things. Critical resources are large[r] numbers of highly educated inventors. Many other countries are increasingly FAR richer in these resources (China, India). We are slipping/will slip much further. No "solution" in the offing.

Three Ways to "Compete"

Price, Quality and Uniqueness. We cannot "win" on Price and Quality. We could "win" on Uniqueness IF we went after a few really tough/frontier, breakthrough areas with multiple solution paths and "protected" the information. For example -- Structural Carbon Nano Tubes, ZPE, Positron Storage, Human-Level Machine Intelligence, "Sense-Making," etc.

People and Nations behave wisely once they have exhausted every other alternative.

Abba Eban

The only person who likes change is a wet baby.

Margaret Mead

NASA LaRC Areas of Technical Excellence

- **Materials** - Polymerics, Nanotubes, Composites, Multi-Functional, Thin Films,
- **Structures** - Aeroelasticity/Flutter, Impact Dynamics and Damage Mitigation/Energy Absorbing, Fatigue and Fracture/Crack Growth, Radiation Shielding, Electron Beam Free Form Fabrication, NDE, Thermal Structures
- **Acoustics** - Jet Noise, Flow Noise, Noise Propagation, Effects on Humans, Structural Acoustics

NASA LaRC Areas of Technical Excellence (cont'd)

- **Aeronautics** - "One Stop Shopping" except for Rotating Machinery Propulsion, Experimental and Theoretical; Aerodynamics across the speed range (subsonic to hypervelocity), General Aviation, Long Haul Transports (transonic and supersonic), Flight Dynamics and Control, Avionics, Air Traffic Control, Flow Control, Crew Human Factors, Safety, Reliable Software

- **Aerothermodynamics** - Hypersonic Propulsion/Scramjets, Convective and Radiative Heating, Aerothermochemistry,

NASA LaRC Areas of Technical Excellence (cont'd)

- **Sensors and Instruments** - LIDAR, Space-Based, Non-Intrusive (passive and active)

- **Systems Analysis** - Aviation/Aeronautics, Space Access, Spacecraft, Multi-Disciplinary Optimization

- **Electromagnetics** - Radar cross-sections, E-M Interference

NASA LaRC Areas of Technical Excellence (cont'd)

- For each of these areas of Technical Excellence, the Center has world-class technical staff PLUS computational science/technology and experimental facilities including "wind tunnels," "simulators," and aircraft

Example Non-Aerospace Applications for/of NASA LaRC Technical Expertise
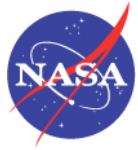
- "**Industrial Aerodynamics**" - "Street Canyons," HVAC, Other Transportation (car/train/bus/truck/submarine), street lights/signs, trash cans, building design for hurricane loading, shelter belts, windmills, towers, bridges, UAV's for traffic monitoring,

- "**Industrial Acoustics**" - HVAC applications, customer-pleasing appliances

Example Non-Aerospace Applications for/of NASA LaRC Technical Expertise (cont'd)

- **Sensors/Instruments** - Medicine, building, infrastructure NDE & "health monitoring," safety/security/force protection, HVAC, fluid level, pollution/environment

- **Energy,Warming** - Composites for reduced weight (transportation), Flow Control for Drag Reduction, High-Efficiency Thermal-Electric Conversion, Systems (including life cycle cost) analysis of alternative energy sources and conservation approaches, fuel cell membranes, piezo-electric energy harvesting, solar concentrators, insulation, solar plant siteing